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GRASSLAND RESEARCH.

THE trend of agricultural policy in many parts of the Colonial Empire during recent years has been towards the establishment of a more settled and permanent system of agriculture. It is generally agreed that the successful development of such a policy should be linked up with the introduction of a suitable system of mixed farming to replace various systems of agriculture which, by exploiting the large stores of fertility of virgin tropical soils, have brought about in many places widespread and progressive soil exhaustion and erosion. Mixed farming is advocated to-day largely because it involves keeping part of the land under a soil recuperative cover of perennial grasses or forage crops on the assumption that this will restore to worn out soils not only the physical and biological characteristics associated with good land but also that granular structure which has been described as the "only structure having any agricultural value at all". By combining livestock with arable crops, mixed farming also provides for a ready supply of organic manure for the arable fields. In short, it is a system designed to ensure the maintenance of soil fertility ; and since it is likely to occupy an important place in the permanent agricultural systems of the future much more attention has recently been paid to grass and forage crops in view of their potentialities as makers and conservers of soil fertility.

It must be admitted that in the tropics grassland research is one of the younger branches of agricultural science and that its position still lags a good way behind that obtaining in the temperate zone. For reasons which we have already given there has of late been, even in the tropics, a more progressive attitude towards grassland problems. Investigations have already shown that the general principles of the good management of livestock and arable land in temperate regions apply also to tropical conditions but that in the tropics there is still much to learn about the best methods of putting these principles to practical use. In the wet tropics, for example, the exact influence on soil fertility of cultivated grass crops under varying field conditions still remains to be assessed. So far it has also not been possible to produce economically a good semi-permanent pasturage of mixed sward equivalent in quality to a first grade English ley although it is hoped that this will eventually be

achieved when more is known about the ecological conditions necessary for the establishment and maintenance of permanent pastures under tropical conditions. On the other hand, surveys of the natural vegetation, including the regional classification of grasslands have already been made in several Colonies where, through the study of the indigenous flora, considerable progress is reported in the isolation of pasture plants for the establishment of cultivated grass crops in rotation with arable crops. The discovery of suitable leguminous plants for establishing in mixture with grasses has, however, proved much more difficult and although for some areas such plants are available, much further work in this direction is necessary. Useful investigations have also been carried out on the management of natural grassland types and on individual species with a view to the improvement of such pastures.

In an article which we publish in this issue the present practice in regard to cultivated forage grasses and their utilisation in the wet tropics is discussed. It will be seen that much more accurate scientific data are urgently required for tropical forage grasses to determine their cropping qualities, to assess their nutritional values at different stages of maturity and under different systems of management, and to provide an economic evaluation of their utility for soiling or grazing. On a limited scale during the last ten years, investigations have been carried out by the Imperial College of Tropical Agriculture on a few of these cultivated tropical grasses grown as soiling crops. Recently this research has been extended to include on a small scale a number of digestibility trials with cattle in order to determine approximately the starch equivalent values of some of the more popular fodder crops at the optimum stage of maturity. Only the fringe of these problems, however, has been touched and much more work will have to be done on them not only in Trinidad but elsewhere. We are glad to learn, in this connection, that the Imperial Bureau of Soil Science is collaborating with the Imperial Bureau of Pastures and Forage Crops in the preparation of a bulletin provisionally entitled "Grassland and Forage Crops in Rotations", which will comprise a survey of present world trends in the evolution of grassland husbandry as a means of producing and maintaining fertile soils which will form a stable foundation for permanent agriculture. This survey should contain a considerable amount of pertinent information on grassland matters which should be of much value in the planning of future investigations on this subject in the tropics.

A NEW METHOD OF PLANT PROPAGATION.*

In a letter published in *Science*, Vol. 94, No. 2429, 1941, P. P. Pirone of the New Jersey Agricultural Experiment Station describes a new method of rooting plant cuttings without sand, peat, soil or other solid media. This has been under investigation since early January of this year. Based on the principle that cut stems suspended in the very moist atmosphere of a specially constructed box can develop perfectly normal roots, the method has already given promising results.

The experimental boxes are approximately 3 feet high, 2 feet wide and 1 foot deep. Each box has a glass front and back; the former is set in grooves so that it can be opened to permit air circulation, and the latter is kept closed but enables observation of root development and of the moisture content in the back of the box. One-inch square removable shelves, made of ordinary builder's lath, are placed in a horizontal position about half-way in the box. A half-inch opening is left between shelves, and vertical wooden strips are nailed on the sides of the box in front of the shelves to hold the shelves in place. A large piece of sheet rubber, with holes of the size of the cuttings to be inserted, is fitted securely immediately behind the shelves. The rubber functions to confine the moisture in the back of the box where it is most needed and to keep the cuttings in place. A water trough in the upper back part of the box from which strips of absorbent cloth are suspended, supplies the moisture necessary to maintain the high humidity.

Successful rooting of a number of popular ornamentals, including Achyranthes, begonia, chrysanthemum, coleus, geranium, perennial phlox, ivy and Philodendron was achieved by this method in less than three weeks. Such plants were then successfully transplanted to soil in pots and have continued to develop normally. Dormant hardwood cuttings were placed in similar boxes in late January and early February. Vigorous roots developed in six to eight weeks on *Hydrangea grandiflora*, *Deutzia crenata* and *Philadelphus coronarius*. These plants were also successfully transplanted to soil and have continued to grow normally.

In all the experimental boxes thus far used, root development was greatest in the vicinity of high moisture content and was either poor or entirely absent in those parts of the boxes where the atmosphere was relatively dry. With improvements in methods of maintaining a saturated atmosphere in the vicinity of the cut stems in the back of the box, this new method promises to be useful not only to commercial growers but also to the amateur propagator. The special type of box in which the present investigations were conducted is tentatively called the "Rutgers Aero-propagator."

* Journal Series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Plant Pathology.

GRAZING VERSUS SOILING IN THE WET TROPICS.

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There is a growing conviction among scientists and farmers alike that the key to successful farming in many localities is to be found in the adoption of a system known as alternate husbandry in which the cropping rotation includes a temporary ley of so many years' duration. This system makes it possible in each field to alternate periods under the plough with periods of soil recuperation under grass. At the same time it brings to the fore the position of livestock in the general economy of the farm, and it postulates the establishment of a good type of ley in order to feed the stock as cheaply as possible and ensure the necessary degree of soil improvement during the limited periods that the land is grassed down. Recent research has immeasurably widened our knowledge of pastures and forage crops in temperate climates and a better conception of their importance and cropping possibilities has been obtained. Actually, this line of research has progressed sufficiently in the temperate zone to allow a suitable working technique to be formulated for the establishment, maintenance, and utilisation of good temporary leys in most arable areas. In fact, the stage has been reached in which the more progressive farmers are beginning to put into practice the information derived from recent investigations on pasture problems.

In the wet tropics, the position in regard to grassland research and corresponding farm practice lags a good way behind that obtaining in cooler climates, though it must be admitted that all over the tropics also there are signs of improvement and a more progressive outlook in these directions. For example, the importance of forage and grass crops and of livestock in the maintenance of soil fertility is being gradually realised and attempts are being made to evolve a practical farm economy based on an appropriate system of mixed farming. Within the last few years, scientific investigations on stock and forage problems have shown considerable expansion. This research has proved that the general principles for the good management of livestock and of arable land in temperate regions apply also to tropical conditions, but that in the tropics there is still almost everything to learn about the best methods of putting these principles to practical use. In the wet tropics, for example, the production of a good semi-permanent pasturage of mixed sward equivalent in quality to a first grade English ley is still not feasible, although ultimately when scientific knowledge has sufficiently advanced, the tropics with its longer growing season may well outclass the temperate zone in the type of pasture that can be established. In an earlier publication,* the writer has already expressed the opinion that immediate improvement in the quality of tropical forage will most easily be attained by the cultivation of perennial tropical grasses, scientifically managed and manured and cut rotationally at the optimum stage of maturity for feeding to stock in the form of green fresh-cut herbage. On this soiling system, the nutritive quality and the yield per acre from a suitable species of perennial grass should both be highly satisfactory. For many of the commoner types of fodder grass, a suitable cultural technique based on scientific evidence can already be specified. In the wet tropics, this soiling system of fodder production should yield from 30 to 100 tons of green herbage per acre per annum or the equivalent of from 5 to 15 tons of dry matter having a nutritive value about the same as good meadow hay. Properly managed, the system represents a marked advance on present practice in which commonly any available type of coarse, often fibrous, and mature roughage of varying and unknown nutritive value is fed more or less *ad lib.* The proposed soiling system using cultivated perennial grasses could be aptly described as an intensive form of forage production capable of giving a steady return and a high yield of good quality roughage from a relatively limited acreage. In contrast to a system of management in which the livestock provides its own roughage requirement by grazing, the labour and cultivation costs per acre on the soiling system must inevitably be high; but within the limits of existing knowledge of tropical pastures and forage crops, the latter method is undoubtedly the surest way of extracting from any area the maximum return of nutritious forage without undue depletion of soil fertility.

* *Jl. Agric. Sci.*, 25 (July 1935), pp. 369-95.

The Grazing of Tropical Forage Crops.

The soiling system, however, is not the only method of feeding perennial cultivated grasses to livestock, as it has been demonstrated in practice that a number of these grasses also make excellent pastures. At this point it is important to note the fundamental difference between such pastures and an ordinary English ley. The latter is characterised by a close-grazed matted sward of mixed grasses and legumes whereas the former commonly consists of a more or less pure stand of a relatively tall clump or tangled grass, which makes no attempt to form a turf or sward in the true sense of the term. In fact, the latter type of grazing might be defined more accurately by the term 'forage' instead of 'pasturage'. Such tropical forage crops are occasionally established from seed, but are more commonly propagated vegetatively from runners, cuttings or root sections planted out by hand after a thorough preliminary cultivation. The grass is not grazed until it has become well established and a good thick vegetative

cover produced. Depending on the particular species and system of management, it will then be grazed either rotationally by folding the stock or else as an open pasture over which the animals are allowed to roam and feed at will. In either case, the head of stock allowed on any area is limited to a number that will restrict the intensity of the grazing in any season to a level that will not adversely affect the general virility of the grass. At certain seasons as during prolonged drought or after heavy rains grazing may even be temporarily stopped. Not all the available fodder grasses are suitable for pasturage as some species tend to die out as a result of the trampling of the grazing animals. Of the non-turf forming grasses which are being used with conspicuous success as open pastures in Puerto Rico, and Brazil, the following are the most popular.

Guinea Grass (*Panicum maximum* Jacq.)
Molasses or Wynne Grass (*Melinis minutiflora*, Beauv.)
Malojillo, Para, or Mauritius Grass (*Brachiaria mutica* (Forssk) Staph.)
Rhodes Grass (*Chloris gayana*, Kunth.)

It is generally agreed that Guatemala Grass (*Tripsacum laxum* Nash) and Elephant Grass (*Pennisetum purpureum* Schumach) are more adapted to the soiling system and do not stand up well to pasturing, although Merker Grass, which is a variety of Elephant Grass, is rotationally grazed in Hawaii. When a suitable species is used there is no doubt of the success of these cultivated grasses as pastures. For example, in Brazil in the Sao Paulo province, a natural campos consisting of herbage deficient in good grasses and poor in chemical composition is being steadily replaced by one or other of the above mentioned species. The quality of the ultimate forage is reported to be excellent as proved by the rapidity with which store cattle using these pastures reach the chilled beef stage. Moreover it is reckoned that the fattening of the animals on this improved open range is the only method of feeding compatible with the economic conditions under which the animals are got ready for the meat market.

Comparison of Cultivated Forage and Fodder Crops.

When it is possible to make a really satisfactory pasture out of many of these cultivated grasses it may appear strange that the soiling system of feeding the herbage to the stock should even be considered. Actually, however, depending on conditions, both systems have their uses, and a brief discussion of their relative merits will not be out of place. One of the fundamental differences of the two methods of management is the question of costs. Obviously the soiling system is much the more expensive, as it involves the cutting and carting daily of the whole of the roughage fed to the stock, and when it is remembered that with cattle, each animal may consume up to one hundred pounds of green herbage per day, the cost of harvesting is no negligible matter. Pasturing has the further advantage that it ensures a cheap and direct manuring of the land from the droppings of animals, although even this advantage is partially offset by the increased risk of encouraging pests and in particular intestinal parasites to which the stock may be liable. It is generally true, however, that grazing, because of the extra freedom and exercise that the animals enjoy tends to keep them in better health than stock confined for a good proportion of the day. On the other hand, grazing in the tropics during the heat of the day is not an unmixed blessing, and for stock such as imported or half bred dairy cattle not fully acclimatised, a good type of byre designed to meet tropical conditions might be considered to give better temperature control and ensure proper conservation of the animals' energies towards productive output. Furthermore, grazing may involve a considerable expenditure in fencing or in herding the stock in order to keep it within the boundaries of the pasturage. By soiling, also, a much better control of both the forage grass and the stock rations is ensured, as the quantity cut from any area, the stage at which it is cut and the amount fed to each animal can all be pre-arranged. Lastly, experience and observation seem to show that tall cane-like grasses such as Elephant Grass are capable of giving a heavier gross yield per acre than the more typical forage species like Para, Molasses or Rhodes Grass. And it is just these same tall high yielding grasses that in general are least fitted for grazing. Guinea Grass, which may be used for fodder or forage, can be regarded as a dual purpose grass being cane-like in habit, but only average in height, in yield, and in its powers of withstanding successfully the trampling of the grazing animal. If this generalisation about the high yielding capacity of the taller grass species proves widely true, it means that for maximum yield per acre—an important feature where land is limited or expensive—fodder and not forage grasses will be resorted to in preference, for stall feeding the animals.

Fundamentally, therefore, soiling is a more intensive system of management with all the advantages that such a system gives in regard to high yields, cultural control, large head of stock per acre, and quantity and quality of ration fed but with the complementary disadvantages of higher costs of operation and additional expenditure on cultivation and manuring. For working animals or dairy cattle giving a high yield of milk, it may be the only practical method of ensuring that the stock has the opportunity of consuming the necessary number of pounds of food without the addition of considerable quantities of concentrates. For fattening store cattle for the meat market, for wool production, for the maintenance of working animals in the slack seasons of the year, grazing has everything in its favour, and the better the quality of the forage the wider its range of utility for the feeding of farm animals.

A carefully controlled system of rotational grazing occupies a position as a method of management about midway between the soiling and open pasture techniques.

The Biotic Factor in Forage Crop Investigation.

Which method of management would be best in any given locality is at present an open question, and the scientific investigation of their relative merits would form an interesting field for research of considerable practical importance. Actually, the best solution in many cases will come from a happy combination of the various alternatives, with one predominating and deciding the general character of the system. For example, on a pasture farm, a small area of cultivated fodder grass kept in reserve for supplying roughage during the closed grazing season, for providing silage or hay for storage, or for supplementing the rations when the grazing is below average would be of great benefit. Similarly, on a farm where the soiling system is followed, one or two small fenced paddocks would be of considerable practical utility. In any case it is certain that the system of management selected will have a fundamental effect on the organisation and character of any farm. For example, it would determine the size of the labour roll, the head and type of livestock, the system on which it is reared, and even the form of the marketable produce. The investigations would be in the nature of long range research of some complexity as a period of years would be necessary before it would be possible to obtain an accurate idea of the reactions to the systems of management of such basic factors as species of grass, cultural care, maturity of the herbage when cut, fertilising programme, persistence of the herbage, soil fertility, and in particular, net profit per acre. Even the technical side of the problem is far from simple, as in grazing, the biotic factor or the influence of the grazing animal on the pasture is of primary importance whereas by the soiling method it is non-existent. There is no doubt of the basic importance of this biotic factor in determining the character and composition of any pasturage. In fact it has been stated that grasslands are largely maintained as such under the influence of the grazing animal; were the latter eliminated, grasslands would revert to scrub and ultimately to forest in ordered stages, and this is particularly true under wet tropical conditions. Grassland has also been described as "the plaything of soil, climate, and the biotic factor, and this last is the master factor." Research work on pastures in the temperate zone has demonstrated conclusively that the botanical composition and dominant characteristics of any sward can be radically altered in a comparatively short period by any marked change in the intensity or the type of grazing to which it is subjected. The effect of the grazing animal on a forage area is likely to be even more marked than on typical pastures, and it is probable that very careful control of the grazing will be required for the proper maintenance of such forage crops over long periods. For example, where temporary mismanagement of the grazing on pasture land would produce a relatively unimportant change in the botanical composition of the sward, in a forage area it might result in the dying out of a good proportion of the cultivated grasses and in consequence give access to weed growth of little or no nutritive value or expose the soil to eroding agencies.

The Research Problem.

There are thus some obvious difficulties in obtaining a scientific comparison of the two systems of management, soiling or grazing. When the herbage is used as a soilage crop, reliable data on such questions as yield, composition, nutritive value, and persistence of the crop can be obtained, but when the land is grazed, a satisfactory estimate of the quantity and quality of the herbage consumed by the stock cannot readily be procured, and it is almost impossible to find a suitable quantitative measure of the cumulative effect of the grazing animal on the general character of the pasturage. Various devices have been used with soiling crops to try and simulate grazing conditions, but it is doubtful whether these are anything but artificial and rather unsatisfactory substitutes for one of the key factors in the problem. In the opinion of the writer they can only serve as temporary expedients which may be capable of demonstrating major differences in the response of forage grasses to soiling and grazing, but they cannot hope to provide a final evaluation of the two methods as practical alternatives for the management and maintenance of livestock on a farming scale.

To tackle the problem effectively, for each management system, comparable estimates of the following factors or their equivalents are required:

(*a*) Grazing capacity.
(*b*) Cost per unit of marketable produce.
(*c*) Number of marketable units produced per acre per annum.

Grazing capacity is a comprehensive term which has been defined as "the maximum number of livestock which a range area will support under the most suitable management over a period of years without injury to the soil, forage, tree growth or watershed, or unwarranted interference with other services of the land". In this definition, it is important to note that a good system of management and its general effects over a lengthy period on both crop and soil are particularly specified. By merely changing the term 'Grazing Capacity' to 'Stock Capacity', the same definition might easily be extended to cover an area of a perennial forage crop worked on the soiling system. The other two requirements, the cost and the number of marketable units per acre are self explanatory. To a certain extent the latter will be dependent on grazing or stock capacity, but in addition it provides a

measure of the rate at which the stock or the stock produce is being got ready for market. This feature is not necessarily taken into account in the estimate of grazing capacity, but it is essential if a fair idea of the whole economy of each system is to be obtained.

Investigations of this nature do not readily fit in with the ordinary small scale field trial technique. Valid conclusions would not easily be derived from the yields and behaviour of so many replicated experimental plots, but they might be formulated from close observation of the behaviour of crop, stock, and soil when a workable acreage of a pasture or forage grass is operated for a reasonable period of time on one or other of the alternative systems of management. This method of approach verges on what has been termed Pasture Control, *i.e.* the evaluation and recording of grassland productivity on the farm as distinct from its study in purely experimental work. Pasture control has been applied by farmers in Europe with considerable success, and in many cases it has led to a complete reorganisation of individual farms on a more profitable basis. Briefly, the system consists of reducing all the products of grassland—green herbage, hay, maintenance feed, live weight increase, milk production, etc.—to one common denominator. In English speaking countries, the norm that has been suggested is the Grassland Performance Unit or G. P. U. The following scale of values has been adopted, on the understanding that some of them *e.g.* milk or hay may be modified in accordance with known variations in the quality of the produce to which they are to be applied.

1 G.P.U. = 1 Kg. liveweight increase.
= 24 hours maintenance for one head of cattle.
= 10 Kg. milk.
= feed for 1 working day for one horse or ox.
= 25 Kg. green herbage.
= 8⅓ Kg. hay.

(1 G.P.U. = 2.5 Kg. Starch Equivalent).

The system must still be regarded as being in the experimental stage and the scale of values may ultimately have to be modified in the light of further experience. Even in its present form, it gives the farmer a working method of estimating the total productivity of any area of pasturage or grassland. It is certain too that when the scale of values has become standardised the system will be put on an international basis for purposes of comparison of grassland productivity in different countries.

An extended economic survey on the above lines carried out by competent observers on a number of selected farms would provide reasonable estimates of grassland productivity under the various systems of management at present in use in different colonies, and might indicate simple and profitable improvements on present practice. It is not suggested that such a survey should entirely supersede more scientific research into grassland problems. There is need for both types of investigation. Pasture control or some suitable equivalent is apparently the best available method of measuring the practical economy of a particular system of grassland management, especially in cases where the biotic factor has to be taken into account. In addition, scientific data are needed to determine the relative merits of different species and mixtures, nutritive values, grazing and harvesting techniques, fertiliser requirements, and so on. In particular the effect of the crop and the system of management on soil fertility requires early investigation. The utility of perennial forage crops, either grazed or soiled, for purposes of soil recuperation has still to be determined. It seems unlikely that they will be as effective in this direction as a good English ley, and it is certain that the soil reaction to the different species with their widely divergent habits of growth will show considerable variation. Such data would accrue only from investigations of a more technical character planned in accordance with modern principles of experimentation, and designed to establish the fundamental facts from which an improved standard of grasslands as a whole would ultimately be evolved. Conjointly with such research, the pasture control technique could be used to test the efficiency of existing pastures and forage crops under alternative systems of management.

The comparatively recent discovery that many cultivated tropical grasses make excellent pastures of a rather unusual type leaves the stock farmer with the difficult question of deciding whether he ought to graze or stall feed his animals. As already pointed out the two systems differ fundamentally and the choice of method may determine the success or failure of any given farm. There is real need for further information on the problem, and it is for this reason that the preceding short discussion of the existing state of affairs has been given, together with suggestions of the lines along which investigations in the immediate future should be directed.

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ZEBU (BRAHMAN) CROSS CATTLE AND THEIR POSSIBILITIES IN NORTH AUSTRALIA.

In an article under this head, published in the *Journal of the Council for Scientific and Industrial Research**, an account is given of the results of cattle breeding experiments carried out by the Council at the suggestion of Dr. R. B. Kelley, of the Council's Division of Animal Health and Nutrition, as a result of his enquiries, early in 1931, into similar investigations in the United States. The experiments were initiated by the Council to establish, among other things, whether it would be economically sound to use cross-bred Zebu cattle in the tropical regions of Australia instead of locally bred descendants of British breeds, and to discover the most suitable hybrid. A group of pastoralists of North Queensland who control large numbers of beef cattle intimated their willingness to co-operate in carrying out the suggested experiments by providing funds for the purchase and transport of Zebu cattle from America and Australia, by supplying British cattle for hybridization, and by maintaining these cattle and their progeny. The Council planned and supervised the experiments so as to collect as much relevant data as possible. All breeding was conducted under its guidance and no cattle or their progeny could be disposed of without its consent and approval. In 1933, Dr. Kelley revisited America to select a number of Zebu male and female cattle sufficient to make experimentation possible.

The experimental herds, now five in number, are on properties north of the Tropic of Capricorn. A recent census disclosed that they contained 5,109 cattle descended from the nineteen animals imported in 1933. By suitable back-crossing of the half-bred progeny of Zebu and British cattle to parental breeds, a range of "percentage-blood" cattle has been made available for examination. In those experiments Shorthorns, Red Polls, Black Polls, Jerseys, and Herefords have been mated to the Zebu bulls, and in addition, a small pure-bred Zebu herd has been formed.

* Vol. 14, No. 2, 1941.

The observed characters of the hybrids, particularly with regard to colour and temperament are closely associated with those of the basic British breed and with the percentage of Zebu "blood" in the hybrid.

In first crosses, the pronounced Zebu hump is considerably reduced, the ear length is shortened, and perhaps the most noticeable difference of all, the back line is straightened. Other obvious generic characters are the shortness of the hybrid coats, the looseness of their skin (particularly at the umbilicus), and the lyrate shape of their horns.

It is generally considered that the tractability of the hybrid is inversely proportional to its percentage of Zebu blood. Experience has shown that, for cattle seldom handled, 25 per cent. Zebu should be regarded as the maximum, and that as far as tractability is concerned, the optimum for all other conditions is between 25 and 50 per cent. Emphasis is placed, however, on the intelligence of the hybrids and the speed at which they can be trained.

It has been observed that the hybrids browse upon the "top-feed" of shrubs and trees to a much greater extent than do British breeds. This probably is a factor which operates favourably during bad seasons, because it makes available a further source of nutriment. Further, when half-bred females were being mated with Hereford bulls to produce quarter-breds, the cows could be maintained on country so indifferent that the bulls had to be withdrawn and replaced.

During a bad year, it was noticed that half-bred heifers just prior to parturition and also after weaning were still in excellent condition, and when compared with British cattle of the same age on comparable country they were at least 50 per cent. larger and fatter. Further, quarter-bred weaners were better nourished and bigger than British weaners. The quarter-bred from a half-bred cow is bigger, fatter, stronger, and more vigorous than the quarter-bred by a half-bred bull out of a British-bred cow.

The deterioration of fat hybrid bullocks when held over into the winter dry season is much less evident than with British breeds and gives added proof of the hardiness of the cross-breds. This is an important economic point, for it may permit lengthening of the killing season at northern meat works.

An examination of the statistics of one herd discloses that the customary periodic writing off for mortality among British cattle (Devon and Shorthorn cross) for comparable ages and sexes is reduced by 30 per cent. for the hybrids.

Four of the herds are situated in tick-infested country, and in them it is considered that tolerance to tick infestation can be associated with what is described as the Zebu type skin and coat. It has been observed that among quarter-breds, although most animals have short sleek coats, a few have hair of a length more closely approaching that of British breeds. A greater number of ticks are found on the long coated animals, although in most cases the degree of tick-worry is much lower than in British cattle depastured in the same area. Generally, the available evidence suggests that the progeny of all Zebu breeds, regardless of which British breed is represented by the other parent, have some tolerance to tick infestation, that the degree of tolerance is closely related to the percentage of Zebu blood in the animal, and that for practical purposes the full-blood Zebu is immune. Three-quarter, half, and three-eighth Zebus very seldom show tick worry, but animals which are three-sixteenth Zebu are apparently only slightly more resistant than British cattle.

Records are now available with regard to the weights and carcass types of 91 hybrid bullocks, and it is clear that carcasses from half and quarter-bred Zebus satisfy the requirements of the Australian export beef trade. Seventy-nine bullocks (22 half-bred and 57 quarter-bred) were slaughtered in 1940 for an average dressed weight of 688 lb. and were graded as 86.9 per cent. first grade. These figures are more interesting when it is considered that, under existing conditions in Central and Northern Queensland, first quality grading above 80 per cent. was regarded as meritorious. Although the hybrids appear "leggy", the carcasses have thick and well-rounded hind legs and have been described as indistinguishable from those of British-bred cattle and admirably suited to trade requirements.

Under the conditions of the investigation, no satisfactory observations have been made as to the possibility of more extensive development by the use of Zebu hybrids, of country now not wholly suited to British cattle. It is emphasized that no recommendation is made that Zebus should replace British breeds in areas with a mean annual temperature of less than 68 °F., and an average maximum temperature for the coldest month of less than 66 °F. However, the available evidence does suggest that in less favourable areas the hybrids, being hardier, might be used with advantage.

BANANA FERTILIZER INVESTIGATIONS IN JAMAICA.

INVESTIGATIONS of the effect of fertilizers on bananas are few in number, particularly in the great producing areas in the Caribbean region. In Jamaica, where many estates have been long under cultivation, and where Panama disease and soil erosion are tending to force cultivation on to new areas of lower fertility, a full knowledge of fertilizer requirements is rapidly becoming of paramount importance. The results of recent investigations by Croucher and Mitchell (*Bull.* 19, Dept. Sci. and Agr., Jamaica, 1940) are of both theoretical and practical interest, touching as they do on several aspects of the growth requirements of the Gros Michel banana.

The experiments under discussion were begun in 1932, but a succession of hurricanes and droughts prevented the reaping of several of the earlier crops, affording, incidentally, some impression of the difficulties with which the tropical investigator has to contend. The experiments undertaken were of a qualitative type, designed to give information on the general reaction of the banana to applications of the main plant nutrients. In the four different areas selected for experimental plots, different results were obtained: in one a growth response was obtained from nitrogen applications alone; in a second, response was obtained only when potash was applied, but phosphate improved production in the presence of potash; on the other hand, excess phosphate in the absence of potash adversely affected the quality of the fruit produced; in a third area, response was obtained only when phosphate was applied, but, in the presence of this nutrient, further response resulted from applications of potash and nitrogen; in a fourth area, absence of potash precluded the possibility of obtaining commercial fruit.

This brief statement of some of the results so far obtained indicates the wide and useful field that awaits further exploration. The assessment of yield of bananas is not a simple matter, in that it involves a consideration of (*a*) the number of 'hands' per bunch, (*b*) the quality of the individual fruits, (*c*) the rate of production, and (*d*) the population of plants per acre. In some areas nitrogen applications produced an increase in the length of individual fruits—a desirable commercial feature; in others, applications of nitrogen and phosphate also increased the length of fruits, whereas adverse results were obtained elsewhere; potash applications tended to offset undesirable effects resulting from phosphate fertilizers.—(*Nature*, **137**, 3733, 1941).

CITRUS ROOTSTOCK TRIALS IN SOUTHERN NIGERIA.

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Introduction.

IN 1932, experiments were laid down at Moor Plantation, Ibadan, and at Agege, near Lagos, to determine the most suitable rootstock for grapefruit and oranges in Southern Nigeria. For the very little citrus work that had been done in the early years of the Department, the acid lime had been used, but though this gave a large tree it was liable to gummosis. After the last war, interest in citrus cultivation in the tropics increased enormously and the sour orange came to be regarded as the best stock for regions of high rainfall and humidity. It was therefore necessary to determine whether it would prove the best stock for Nigerian conditions or whether some other stock would be more suitable.

Experimental Details.

Of the two stations where the trials were laid down, Agege lying nearer the sea has a slightly higher rainfall, 53 inches per year, than Moor Plantation's 49 inches and a rather less severe dry season. The soil at Agege is also somewhat heavier than the light well drained, sandy soil found on Moor Plantation.

The rootstocks to be tested were the sour orange, sweet orange, acid lime, rough lemon, grapefruit, shaddock and tangerine. Unfortunately, seedlings from the same stock parent were not always available so the origins of all the stock material are not known with certainty, and also, it was subsequently discovered that the rough lemon used was not the true rough lemon but probably a hybrid variety of rough lemon. This forms a very poor root system and its undoubted failure has upset to some extent the statistical analysis of the experiment.

For the grapefruit scions two local selections M.P. 2 for Moor Plantation, and M.P. 18 for Agege, were used. None of the more usually recognised commercial types such as Marsh Seedless was available at that time.

The budded stocks were planted in a randomised block layout using single tree plots with six replications so that there were in each experiment 42 stands, that is six replications of the seven stocks.

The orange trials were laid out in exactly the same way, the scions being the local selections M.P. 64 at Moor Plantation and M.P. 77 at Agege.

The exact history of these four scions is not known. They were very early introductions budded on acid lime stocks and selected as the best available at that time.

The sweet orange stocks used in these trials also came from introduced material and these parent trees are not the same as the local native green skinned sweet orange.

The seeds were planted in the rainy season of 1930 and budded at about 18 months. No standard height of budding was used and by modern standards they were budded far too low, generally at about 12 inches from the ground. The young budded plants were kept in the nursery for a year.

Planting out was done in June 1932 in the rainy season. The stands were holed and filled with surface soil so that the young budded plants were raised six inches above average ground level. Calopogonium cover crops were interplanted and the only cultivation has been periodic ring weeding.

The spacing adopted at Moor Plantation was 27 feet triangular and at Agege 25 feet square. These two spacings give practically the same number of trees per acre, 70 for the triangular as against 69 for the square spacing, but it is likely that the triangualr spacing utilises the ground to a better extent.

Pruning in the early years was confined to producing a well balanced scaffold. In later years little pruning was done beyond the removal of water shoots arising in the centre of the tree.

The failures were replaced the following year but in some cases, notably the rough lemon stocks, 4 or 5 years elapsed before they were established and this has had to be considered in analysing the yields.

The trees at both Moor Plantation and Agege are now nearly touching and it would seem that the spacing adopted was too close. Further planting will be done at 29 feet triangular giving 59 trees per acre.

Yields.

A few of the trees bore fruit in 1935 and all but the failures in 1936. At the end of the 1939 season, that is, March 1940, yield figures were available for 4 full years and a comparison of these yields follows (Table I). The total for 4 years has been used rather than for single years to obviate the problem of biennial bearing.

The analysis of variance was done for each trial with the exception of the Agege orange trial where failures and vacancies did not allow of any statistical analysis.

In the Moor Plantation orange trial and Agege grapefruit trial modifications had to be made by omitting the rough lemon and shaddock stocks and calculating a missing plot in each case.

Where significance was shown at the 5 per cent. point, the standard errors of the mean were obtained and are shown in the tables. The Agege grapefruit trial showed no significant differences between stocks.

Table I.

GRAPEFRUIT TRIALS.
(Average yield per tree for 4-year period.)

Stocks.	Moor Plantation: Scion—MP2.		Agege: Scion—MP18.
Sour orange	2,261	±239	932
Sweet orange	1,820	±239	976
Acid lime	1,754	±239	580
Grapefruit	1,660	∓239	894
Tangerine	1,435	±239	574 (4 trees only)
Rough lemon	1,198	±239	—
Shaddock	1,123	±239	881

ORANGE TRIALS.
(Average yield per tree for 4-year period.)

Stocks.	Moor Plantation: Scion—MP64.		Agege: Scion—MP77.
Sour orange	2,718	±266	1,742
Sweet orange	2,437	±266	1,703
Tangerine	2,060	±266	1,260
Acid lime	1,989	±266	1,087 (4 trees only)
Grapefruit	1,179	±266	1,048 (do.)
Shaddock	1,299 (4 trees only)		859 (do.)
Rough lemon	838 (5 do.)		—

Table II.

GRAPEFRUIT TRIALS.
(Measurement in Inches.)

Stocks.	Moor Plantation. Scion MP2.		Agege. Scion MP18.	
	Scion girth.	Stock-Scion.	Scion girth.	Stock-Scion.
Sour orange ...	28.1±2.3	+1.6±0.6	23.7	0.0
Sweet orange ...	27.3±2.3	+0.3±0.6	25.2	−0.7
Acid lime	28.7±2.3	+3.8±0.6	20.6	+5.4
Grapefruit	23.8±2.3	+2.2±0.6	25.7	+1.5
Tangerine	29.5±2.3	−1.8±0.6	25.2	−2.0
Rough lemon ...	17.8±2.3	+4.1±0.6	—	—
Shaddock	20.8±2.3	+4.1±0.6	24.8	+5.0

ORANGE TRIALS.

Stocks.	Moor Plantation. Scion MP64.		Agege. Scion MP77.	
	Scion girth.	Stock-Scion.	Scion girth.	Stock-Scion.
Sour orange ...	24.3	+1.6	21.2	−0.2
Sweet orange ...	25.3	+0.8	24.2	+0.2
Tangerine	26.2	+0.6	25.3	+1.7
Acid lime	27.0	+4.3	22.0	+3.2
Grapefruit	23.8	+0.8	22.7	+1.0
Shaddock	17.2	+1.7	17.5	+2.2
Rough lemon ...	14.2	+0.6	—	—

The rather high values of the standard errors may be attributed in part to the great variation in plot yields and would indicate that the single tree plot is not satisfactory for this type of trial.

In every instance, except the Agege grapefruit trial, the sour orange heads the list closely followed by the sweet orange. The tangerine proves a rather better stock for oranges than for grapefruit, but the grapefruit, shaddock and rough lemon stocks are comparative failures.

Girth Measurements.

In December, 1939, after the trees had been planted out for seven years, measurements were taken of the girth of the stock and scion, 3 inches below and above the bud union.

The average scion girths follow in order of yield (Table II), and this table also includes the average difference between the stock girth and the scion girth for each type of stock. This measurement gives an indication of the smoothness of the bud union.

In the Moor Plantation grapefruit trial both scion girths and differences between stock and scion showed significance at the 1 per cent. point. The statistical analysis was not undertaken for the other trials.

Examination of the figures in Table II indicates that high yields are associated not so much with the actual scion girth as with the compatibility or smoothness of the bud union, that is the smaller the difference between the stock and scion girths, the better the yield. For the Moor Plantation grapefruit trial, the correlation worked out at −0.70 which for seven variates is just not significant at the 5 per cent. point.

Other Measurements.

All the fruit harvested on the Moor Plantation experiments is graded, and an attempt was made to discover any effect of the stock on the size of fruit. No such effect seems to exist, each stock producing its maximum number of grapefruit within the 54 to 96 limits generally accepted by the commercial markets.

Measurements of rind thickness were also made but the variation is too great to admit of any valid conclusions.

At Agege, where facilities exist for the squeezing of juice for bottling, some observations were made on the juice contents of fruits from various types (Table III).

Table III.

No. of Fruit per gallon for each grade at Agege.

Stocks.	Grapefruit.		Oranges.	
	54′	64′	176′	200′
Sour orange ...	21	26	41	56
Sweet orange ...	22	26	50	52
Acid lime ...	20	31	57	64
Grapefruit ...	22	24	36	62
Tangerine ...	26	29	51	56
Shaddock ...	28	32	40	40

The number of fruit used in each extraction varied from 70 to 357 for the grapefruit and from 40 to 350 for the oranges. The figures from this single test serve only to show that considerable variability does exist, but further extractions would be needed before any significance can be attached to them.

The sour orange and sweet orange stocks seem to yield fruits as juicy as any. How far juiciness is bound up with that more intangible property quality is problematical, but on these two stocks the fruit is generally acknowledged to be unsurpassed.

Disease Resistance.

Coming now to what must undoubtedly play a most important part in the final decision of the best rootstock, disease resistance, the data are not very complete. Gummosis has, so far, not appeared on any of the trees at Moor Plantation though it undoubtedly exists on older trees in other parts of the Plantation. At Agege it is more serious and the figures are shown in Table IV.

Table IV.

Trees at Agege Attacked by Gummosis.

Stocks.	Grapefruit Trial.		Orange Trial.	
	Stock.	Scion.	Stock.	Scion.
Sour orange	—	1	—	—
Sweet orange	4	4	—	—
Acid lime ...	2	1	1	—
Grapefruit ...	2	1	1	—
Tangerine ...	1	—	—	—
Rough lemon	1	—	—	—
Shaddock ...	1	1	1	—

The single grapefruit on sour orange that has been attacked was very low budded, about 8 inches above the ground, and the disease appears only on the grapefruit scion and has not travelled down below the bud union.

The infection is high on sweet orange stocks but these are imported varieties. The Nigerian green skinned orange, invariably seedling trees, appears far less susceptible in the field. Of these some very old ones exist at Agege and show little or no trace of gummosis.

Conclusions.

From the point of view of yields alone, none of the stocks is as good as the sour orange with the exception of the sweet orange which runs it a close second, especially for oranges. In many respects the sweet orange would be preferable to the sour orange especially in facilitating the nursery work. It is easier to rear and bud and is not affected by scab disease which plays havoc in the sour orange nurseries even under shade. Also it has the advantage that should the scion die back after distribution to the native farmer, he would still have a sweet orange tree rather than a useless sour orange.

But if the sweet orange stock is going to succumb to gummosis at a comparatively early age it would be useless considering it as a stock. Further trials are to be laid down to compare the Nigerian green skinned orange as a stock against the sour orange, and artificial innoculation with the fungus causing gummosis will be made on old trees and compared with similar innoculation on sour orange standards.

But until this is done, it would be inadvisable to consider the large scale use of any other stock than the sour orange. The superiority of the final tree on sour orange stock justifies the greater trouble and difficulty required in the nursery work.

In Northern Nigeria somewhat similar trials have been laid out but yield figures are not yet available. In the drier environment the rough lemon may prove more successful, but the indications are that, even so, the sour orange will maintain its leading position as the best all round stock.

Summary.

1. An account is given of rootstock trials for grapefruit and oranges laid down at two stations in Southern Nigeria.

2. The yields for a period of 4 years are tabulated and analysed, and the single tree plot is considered unsuitable for this type of trial.

3. Girth measurements of stock and scion are compared.

4. Short notes are given on grading, rind thickness and juice content in relation to the various stocks.

5. Their disease resistance is considered.

6. The general conclusion is reached that, with our present knowledge, the sour orange is the most suitable stock for Southern Nigeria.

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THE EFFECT OF CARBON BISULPHIDE ON THE GERMINATION OF PADDY.

By Gerold Stahel.
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Protection of stored paddy from insects is a serious problem in all rice growing countries. Trials to control these insects in seed paddy with carbon bisulphide have shown the desirability of obtaining some knowledge about the effect of this disinfectant on the germination of the paddy. It was quite clear that the effect would be different by treating dry or moist paddy. For this reason paddy with a moisture content of 2 per cent. to 16½ per cent. was used.

All experiments were carried out with pure seed paddy of the Skrivimankoti variety (Demerara Creole), a long grain rice of the Siam type. This paddy was stored for six months in a large concrete silo. The moisture content was 9.4 per cent. All paddy used in the series of trials was thoroughly mixed and passed through a Boerner sampler five times.

The first trials were made with a CS_2 concentration of 200 cubic centimeters per 1 cubic meter, a common concentration used for disinfecting purposes. The carbon bisulphide used was the crude commercial product. The moisture content of the paddy was 9 per cent., 11 per cent., 13 per cent., 15 per cent. and 16 per cent. Carefully closed glass containers were used for these trials. After treatment the paddy was immediately put into water and after being soaked for 12 hours, laid out in Petri dishes fitted with two wet filter papers.

One hundred seeds were placed in straight lines in the dishes. Every day at about 6.30 and 16.30 the normally germinated seeds were counted and removed. Germinated seeds forming no rootlets, not even after 7 days, were not counted. After 2½ to 3 days the paddy began to germinate, and from this moment the dishes were inspected for a period of 5 to 7 days.

Germination remained unaltered in this CS_2 concentration for paddy with 9 per cent., 11 per cent. and 13 per cent. moisture content even

Table 1.

200 CM^3 CS_2 per 1 M^3.

Moisture content.	Total percentage of germinated seeds treated during.....days.									
	No treatment.	1½ days.	3 days.	4½ days.	6 days.	7½ days.	10 days.	12 days.	14 days.	16 days.
9 %	97	90	100	99	95	88	99	98	96	98
11 %	96	96	93	98	97	99	94	95	96	96
13 %	95	95	96	95	93	96	93	91	93	90
15 %	92	91	93	94	70	63	9	3	0	0
16½%	93	90	94	88	58	48	3	6	0	0

Table 2.

200 CM^3 CS_2 per 1 M^3.

Moisture content.	Percentage of germinated seeds during the first day.									
	No treatment.	1½ days.	3 days.	4½ days.	6 days.	7½ days.	10 days.	12 days.	14 days.	16 days.
9 %	97	70	91	88	71	97	95	92	94	76
11 %	96	67	79	69	18	73	60	46	47	12
13 %	95	51	49	41	15	60	45	43	40	17
15 %	92	39	23	7	0	10	0	0	0	0
16½%	93	36	20	0	0	0	0	0	0	0

after 14 days (Table 1). At 15 per cent. and 16½ per cent. moisture content, however, the germination begins to decline after 4½ and 3 days treatment respectively.

The figures for speed of germination, shown by the percentage of germinated seeds during the first day, demonstrate still better the gradual effect of the CS_2 vapours on the germination of paddy with different moisture contents (Table 2).

A second series of experiments was carried out with treatments up to 36 days using the same CS_2 concentration (Table 3).

Table 3.

200 CM^3 CS_2 PER 1 M^3.

Moisture content	Total percentage of germinated seeds treated during .....days.					
	12 days.	15 days.	18 days.	21 days.	24 days.	36 days.
9 %	99	99	98	96	98	97
11 %	94	93	94	81	94	98
13 %	90	89	59	14	34	10
15 %	20	2	7	1	0	0
16½%	0	0	0	0	0	0
Percentage of germinated seeds during the first 2 days.						
9 %	99	99	98	94	97	80
11 %	89	85	91	24	30	10
13 %	49	67	40	0	1	0
15 %	3	0	2	0	0	0
16½%	0	0	0	0	0	0

These figures show, that even after a treatment lasting 36 days the total germination was still at its maximum for paddy with 9 per cent. and 11 per cent. moisture content. As mentioned above the paddy was put into water immediately after treatment. It is probable, however, that germination might have been higher, had the paddy been ventilated before being put into water.

For this reason a part of the samples of the first series of trials treated during 12, 14 and 16 days was divided in two, one part being ventilated for 12 hours before soaking.

Table 4.

200 CM^3 CS_2 PER 1 M^3.

Moisture content.	Total percentage of germinated seeds treated during.....days.					
	12 days.		14 days.		16 days.	
	Not ventilated.	Ventilated.	Not ventilated.	Ventilated.	Not ventilated.	Ventilated.
9 %	98	98	96	98	98	96
11 %	95	94	96	95	96	91
13 %	91	92	93	93	90	92
15 %	3	0	0	0	0	0
16½%	6	0	0	0	0	0
Percentage of germinated seeds during the first day.						
9 %	92	97	94	99	76	95
11 %	46	89	47	86	12	61
13 %	43	61	40	72	17	24
15 %	0	0	0	0	0	0
16½%	0	0	0	0	0	0

As shown in Table 4 the total number of germinated seeds is the same, whether ventilated or not, but the speed of germination is higher with ventilated paddy.

Further trials were carried out with CS_2 concentration of 2,500 cubic centimeters per 1 cubic meter, 12½ times higher than the concentration used for the first series. All samples were ventilated for several hours after treatment (Table 5).

Table 5.

2,500 CM^3 CS_2 PER 1 M^3.

Moisture content.	Total percentage of germinated seeds treated during .....hours.			
	4 hours.	12 hours.	24 hours.	36 hours.
9 %	100	98	92	93
11 %	99	97	14	2
13 %	100	93	0	0
15 %	100	2	0	0
16½%	65	0	0	0
Percentage of germinated seeds during the first day.				
9 %	100	98	65	38
11 %	99	84	2	0
13 %	99	8	0	0
15 %	67	0	0	0
16½%	11	0	0	0

After a 4 hours-treatment germination is lessened only for paddy with 16½ per cent. moisture content, but after 36 hours only paddy with 9 per cent. moisture content germinated at a high percentage.

To study the behaviour of paddy with moisture contents lower than 9 per cent, paddy was dried in a dry oven down to 2 per cent. The initial moisture content of the paddy was 9.4 per cent. For 12 hours the temperature was raised gradually up to 100°C. and held at this temperature for a further 12 hours. After this time the paddy had a moisture content of 2.0 per cent. and gave a 98 to 100 per cent. germination.

When dried a further 15 hours at 110°C. the paddy was free of water, but did not germinate.

Table 6.

2,500 CM^3 CS_2 PER 1 M^3 TREATED.

Moisture content.	Total percentage of germinated seeds treated during 1 and 2 weeks.	
	1 Week.	2 Weeks.
2%	88	87
5%	99	91
7%	96	100
9%	66	2

The figures in Table 6 show that the germination of paddy with a moisture content of 2 per cent., 5 per cent. and 7 per cent. is still very high even after a two-weeks' treatment.

The experiments were repeated with saturated CS_2 vapour by putting a tube with plenty of carbon bisulphide in the glass container. The vapour condensed at the bottom of the bottle and the paddy was covered with a layer of liquid carbon bisulphide. After two-weeks' treatment the germination percentages were as shown in Table 7.

Table 7.

SATURATED CS_2 VAPOUR.

Moisture content.	Not treated.	Treated during 14 days.
2%	99	78
5%	98	93
7%	100	83
9%	100	1

In view of these unexpected results further experiments with liquid carbon bisulphide were carried out (Table 8). The paddy was submerged in the liquid and became transparent and dark. Only the germs remained conspicuously whitish and opaque. After treatment, the paddy was ventilated during one day, soaked during a further day and laid out in the germination dishes.

Table 8.

LIQUID CS_2.

Moisture content.	Total percentage of germinated seeds treated during..... days.	
	1 day.	5 days.
2%	95	79
5%	96	95
7%	100	98
9%	100	90

Further trials were made with a new series of paddy with moisture contents of 2 per cent., 4 per cent. and 9 per cent. (Table 9).

Table 9.

LIQUID CS_2.

Moisture content.	Total percentage of germinated seeds treated during .....days.		
	Not treated.	7 days.	14 days.
2%	97%	72	58
4%	99%	88	70
9%	97%	82	38

It is striking that very dry paddy thoroughly impregnated with liquid carbon bisulphide still germinates even after 14 days' treatment.

The behaviour of paddy with 9 per cent. moisture content is also noteworthy. In two experiments with CS_2 vapour at high concentrations only 2 per cent. of the paddy treated in one case (Table 6) and 1 per cent. in the other (Table 7) was still able to germinate after 14 days' treatment. With liquid CS_2, however, as much as 38 per cent. germinated, (Table 9) though the speed of germination was very slow, as seen in Table 10.

Table 10.

LIQUID CS_2.

Moisture content.	Percentage germinated seeds treated during 14 days.		
	First 3 days.	Following 3 days.	Later days.
2%	54	3	1
4%	54	16	0
9%	1	20	17

Summary.

It is shown that the poisonous effect of CS_2 vapour on the germination of seed paddy depends closely on the water-content of the latter, at least when it is between 9 per cent. and 16½ per cent.

Air dried paddy 14 per cent. moisture content may be treated with the usual CS_2 concentration for disinfecting purposes as long as 7 days without doing harm to germination. With 13 per cent. that is only 1 per cent. less moisture content, even a 14 days' treatment is not harmful.

Very dry paddy below 9 per cent. still germinates after a 14 days' treatment with saturated vapour or even with liquid carbon bisulphide.

CACAO IN COSTA RICA.*

COSTA RICA was of little importance as a cacao producing country until 1914 when the United Fruit Company, in order to replace financial losses sustained by the decline of the banana industry in this country, replanted parts of the abandoned banana lands to cacao. This was an impetus to the industry and a rapid extension took place. Costa Rica has become the sixth most important cacao producing country of Latin America and the thirteenth of the world. It produced 8,074 tons in 1937. Cacao, however, is of secondary importance to the country, bananas still being the primary industry. Both industries are dominated largely by foreign capital. The coffee industry which is carried on chiefly on the highlands is the mainstay of Costa Ricans. The banana and cacao industries have less to do with the real lives of the natives except to contribute the returns usually received from industries that are exploited by foreign capital.

Practically all the cacao of Costa Rica is produced in the low-lying district of the Caribbean coastal plain, although there is a small amount produced on the Pacific slopes in the hinterland of Punta Arenas where, owing to insufficient rainfall the crop is raised under irrigation. A few thousand pounds are exported every year, but due to the competition of the district on the Caribbean coast and other producing regions outside the country, production of this district figures little in the export trade.

On the Caribbean lowland cacao is planted on available valley land or nearby hillsides in selected spots west from Limon along the Northern Railway to the Reventazon River and also of what is called the "Old Line" that branches off from the main railway at La Junta. In addition to these spots there are areas devoted to cacao south-east from Limon located two or three miles inland from the coast, extending to the Panama border, particularly along the Banano and Estrella Rivers.

Published statistics of cacao acreage are admittedly deficient. Those given in the Government's annual publication for 1928 are 63,113 acres, having over 22,000,000 trees. There was little or no extension the next two years. In 1931 and since, low prices have made the industry unprofitable in many cases leading to the abandonment of acreage and destruction of trees to make room for other crops.

The lowlands of Central America bordering the Caribbean Sea have a rainy low-latitude type of climate. They have high uniform temperatures, high relative humidity at all times and heavy rainfall well distributed throughout most of the year. In most of the areas where cacao is grown in Costa Rica the rainfall which often exceeds 150 inches, (the average being 120 inches), is too heavy for ideal conditions for production. The crop, as a result, is subject to black rot, and one-sixth to one-seventh of the yearly yield is lost through this disease.

The cacao farms are situated in protected sites where the influence of the trades is scarcely felt. Fortunately also hurricanes are unknown. The sites resemble those of Bahia in this respect. Here, as there, the plantations are exposed to the gentle breezes of the trades but not to the violence of hurricanes.

The selection of land for cacao in Costa Rica needs very little attention. Most soils of the Caribbean lowlands are suitable with the exception of the very heavy clays, the sandy or gravelly soils, and swamps. The best soils for cacao are the rich alluvial deposits especially those containing a sufficient amount of clay to give the soil a heavier body than the average light loams. As has been the custom in regions where cacao is usually planted, more attention has been paid to the physical aspects of soils than to its chemical composition. The history of banana cultivation has been a guide. If the banana plant has held

* Abridged from an article by E. F. Keithan in *Economic Geography*, Vol. 16, No. 1, pp. 79-86, 1940.

up well for at least four years the land is usually good for cacao, unless there are some obvious reasons why cacao should not be planted.

Here, as in other cacao regions, the tap root of the tree attains a length of from 3 to 6 feet and should never touch compact gravel, stone, or stagnant water. Most of the areas have soils that respond to these requisites for the majority of them are deep and have a not too high underground water level. The presence of a number of good-sized rivers, the direction of their flow, and the selection of the cacao sites near the many rivers usually insure good drainage. The cacao farms are generally located near the many rivers which traverse this district, and with their fertile alluvial soil and good drainage are conducive to the production of the crop.

Besides having the usual requisites for good cacao soils, Costa Rica has soils that do not "wash", they are as resistant to erosion as the deep sandy soils of the Florida Peninsula even where the texture exceeds in fineness the stiffest North American clay. In Costa Rica and many other parts of Central and South America, the extremely fine textured soils possess perfect physical conditions for absorption and retention of moisture, for prevention of erosion and easy working qualities. These are the rich soils in most cases producing without fertilization of any kind good crops of corn, bananas, beans, coffee, and cacao. Bananas in these soils have given good yields continuously for long periods and have shown little or no decline when unaffected by Panama disease.

Development of the Cacao Industry.

Cacao had been produced in small quantities in the section of Costa Rica adjacent to Limon for about two centuries. When the construction of the railway from Limon to San Jose, the capital, was undertaken, the industry received an impetus and plantings were increased. The production then expanded and the first record of export was in 1895 when 1,984 tons were exported. Earnings on the carriage of cacao were insufficient to meet the operating costs of the partially completed railway line, and planting of bananas was undertaken to provide additional freight and revenue until such time as the road might be opened to through traffic.

Profits on the bananas soon proved to be attractive and banana planting then became, and has since remained, the principal industry of the Limon District, relegating cacao to a distinct second crop. Production of bananas reached its peak in 1913, when 11, 170, 812 stems were exported. In 1935 exports from the same districts amounted only to 2,908,836 stems. As the decline continued, more attention was given to cacao. Bananas exhaust land on the average of eight years. While they may no longer be produced thereon, all the properties in the soil necessary to cacao remain. Rather than permit the land to remain idle, cacao has been put in or put back, albeit returns from the latter normally are but one-third those from the former.

With the decline of banana production and the consequent release of labourers from 1926 on, many have turned to cacao production. These labourers are West Indian negroes for the most part secured by the United Fruit Company for work in the banana plantations. They live in separated houses scattered in the plantations or in villages located near the tram lines which were built first to serve the banana industry and are now devoted in part to carrying the cacao to the main railroad which conveys it with other products to Limon for export.

In 1930, Costa Rica exported 8,064 tons of cacao, which up to that time was its year of maximum production. The average selling price was 5 4/5 cents per dry pound. At such a price there was little margin of profit as a whole, and in the cases of the larger planters, with heavier overhead and plant charges, it has meant losses, and thus it may readily be understood why large planters have been glad to rent plots to labourers who, while obtaining a meagre livelihood, also have prevented the trees from becoming ruined.

The raising of cacao as a commercial crop in Costa Rica is a relatively young enterprise. If the banana industry continues to decline, which is likely, more areas will be released for cacao planting. There are also lands of secondary forest suitable for cacao. Hence the youthfulness of the industry and the available new areas along with government encouragement and plenty of foreign capital may encourage extension of the crop. On the other hand the production is not likely to increase so long as low prices prevail and the cost of labour is so high on the larger plantations.

Preparation for Market.

The methods of fermenting cacao in this region probably represent the most improved methods in Latin America. The old process of piling the beans in heaps and covering them with leaves or earth, or in baskets or barrels lined with banana leaves has given place to the use of scientifically constructed fermenting bins. Instead of the old method of bagging the wet cacao for shipping to the drying plant, tank cars of about 27,000 to 45,000 pounds capacity, with openings on the top and on the sides, are now used to carry the beans in bulk. These cars are loaded from elevated platforms along the railway line to which the beans are brought from the farm by mule-back or narrow gauge tram cars. Some platforms are provided with hoppers. The hoppers are filled as the beans arrive from the farms and are then fed to the cars by gravity, thus making possible the loading of a large quantity of cacao in a very short time.

In order to insure an even distribution of heat during fermentation, the cacao beans are turned every forty-eight hours. To facilitate this

operation, the fermenting bins are built in tiers, so that after the first forty-eight hours, the top bin is opened on the side and dropped directly into the next one and so on to a third one which empties directly into a mechanical conveyor which carries the cacao into the drying drums. After fermentation is complete the wet beans are transferred by mechanical conveyors into drums having a capacity of from fourteen to fifteen thousand pounds each; these drums revolve slowly and are supplied with a continuous flow of hot air, between 130° and 165° F., kept in motion by a strong ventilator. The drying period varies from thirty to sixty hours. As these drums revolve the beans rub against each other, acquiring in this way, a high polish and finish. In spite of a fermentation which seems insufficient and a drying process which is performed at temperatures which are generally held to be higher than is favourable to cacao, the Costa Rican cacao brings a rather good market price.

A small share of the labour in Costa Rica is performed by task but the contract system predominates. The wages paid are the same as those paid to labourers on the banana plantations but less than those paid on the coffee plantations, which are about 50 cents per day. This is partly explained by the direct competition of labour in the banana and cacao plantations. Cacao, as we have cited, is grown in this region on abandoned banana lands and the labour supply for both industries is obtained from the same sources.

The wage of a labourer on a cacao plantation is low but since his standard of living is not high and often his food and shelter are provided by the planter, he does not fare so badly as would appear at first glance. Most of the labour is needed on the plantation for the first five or six years until the trees come into bearing and at each harvesting season. Little is seemingly needed at other times, though more care of trees in their normal development as well as supervision of disease which so often besets them would improve and increase production.

Most of the cacao grown in Costa Rica is on the small-scale farm rented to tenants by the United Fruit Company. These tenant farmers and smaller planters turn over their productions to several firms engaged as merchants and exporters in the several cacao centres. In the past this trading was done by merchants only and payment was made in the form of merchandise and provisions. Within the past few years, the United Fruit Company, which is the principal producer, began offering cash prices and it gradually obtained the lien on small planter production.

This Company has a large drying plant and the more cacao it handled the wider was distribution of overhead and the greater its profits when profits were being made. Since prices have fallen, however, such outside purchases have stopped and the planter disposes of his crop under the best trading conditions prevalent in his particular district.

Cacao growing was looked upon by the United Fruit Company as the golden opportunity to augment the resources of this district when banana production began to decline. At one time it appeared to fulfil this promise. During the last few years, however, prices paid in the world markets have shown so little margin of profit, that a great portion of the cacao bearing is being allowed to revert to jungle and the future of the district is not promising.

The consumption of cacao in the United States has trebled since 1914. Owing to this country's close connection with Costa Rica and the United Fruit Company most of the cacao finds a market in New York and other distributing centres of the east coast. Practically all the cacao is shipped by the Caribbean through Limon which has a good harbour improved by the United Fruit Company since the exportation of bananas in large quantities from this port began. Steamers dock directly at the deep water pier and good facilities for loading and unloading cargoes obtain.

The capacity of the world to absorb larger supplies of cacao can hardly be doubted. Up to quite recently production and consumption were on a par and the industry as a whole was in a very satisfactory condition. Much of the present unsteady state of affairs is from world depression rather than from any immediate cause in the industry itself. It is reasonable to believe that in the restoration of normal times cacao from Costa Rica will possess an enlarged market and experience a return to prosperity to its region of production.

RAISING CACAO SEEDLINGS.

Some practical notes are given in *Landbouw*, XVI: pp. 763-4 on methods of raising cacao seedlings in Java where cacao grows well up to 500 metres above sea level and on a variety of soils. There is an average rainfall of 2,500-3,500 mm. The principal points brought out are as follows:—The seed quickly loses viability if not sown at once. It is cleaned by rubbing in a rough cloth with sand or sawdust and is subsequently dried in airy shade for two days. It is germinated in sandy soil under a rain- and sun-proof thatch. Germination occurs in 10 to 15 days and five days later the seedlings are transferred preferably to baskets 15 cm. diameter, 30 to 35 cm. high, or failing these are planted 20 × 20 cm. apart in nursery beds. The compost must be good garden soil. A lattice shade is provided. The plants are ready for the field in eight months and must be transplanted with a ball of soil and set under light shade, *Tephrosia candida* or *T. vogelii* planted one to three months in advance being suggested as a temporary shade, or *Albizzia falcata* or dadap planted a year in advance as a permanent shade. The plant holes are dug out some months in advance 5 × 5 metres apart. The incorporation of some good stable manure in these holes is advised.—(*Horticultural Abstracts*, XI, No. 2, p. 144.)

THE NATURE OF VITAMINS.

QUESTIONS have sometimes been asked by the sceptical as to what exactly vitamins are, what they really do, and whether, in spite of the vast publicity that has been given to them, they may not after all be just another in the long list of evanescent medical fads. It may be well, therefore, to trace very briefly the history of our knowledge of them; and it may be said at once that their existence was, in the first place, wholly a matter of inference. For many years, indeed generations, it had been within both medical and popular knowledge that certain diseases could be influenced by particular food-stuffs. Scurvy, for instance, was known to appear in the absence of fresh fruit and vegetables, and to be cured when these were restored to the diet. That such foodstuffs should be taken on board for long voyages was advised by the physician Gilbert, the Englishman, mentioned in the prologue of Chaucer's Canterbury Tales. Rickets was another disease known to be due to certain deficiencies of diet and to be curable by such substances as cod-liver oil. But it was the study of beri-beri that immediately led to the deduction of the class of substances known as vitamins.

Beri-beri is an oriental disease, chiefly of rice-eating populations, associated with profound general weakness, neuritis and sometimes paralysis and dropsy. A young Dutchman, Christian Eijkman, working as a laboratory assistant, noticed that some fowls which he had been feeding with polished rice developed a condition identical with beri-beri, and recovered when this was replaced by their normal food. Later it was found that, when patients with beri-beri were given a diet of whole rice, instead of the popular polished or decorticized rice, they immediately began to recover. Eijkman at first believed that the polished rice contained a poison of which the husk was the natural antidote. But Casimir Funk, working at the Lister Institute, found that the symptoms of beri-beri could be produced by an artificial diet of pure carbohydrates, from which rice was excluded. It was therefore not a poison but the absence of some vital factor, that appeared to be responsible for the disease, and later he found that an extract from rice husks was able to counteract the disease. Though afterwards found to contain other substances, this extract obviously contained the specific vital factor, and it was Casimir Funk, twenty-eight years ago, who coined the word vitamine, from which the final "e" was later dropped.

Since then an immense amount of research has been done on the subject by such workers as Gowland Hopkins, the Mellanbys, Plimmer, McCarrison, Windaus and many others, and a whole group of these specific vital factors, or vitamins, has been discovered and, for convenience given an alphabetical nomenclature. Actually they are chemical substances of very complex structure, many of which can now be made in the laboratory, and although a great deal remains unknown as to their precise action in the body, relatively minute quantities having a profound general effect, yet it has now been proved beyond reasonable doubt that, in their various ways, each of them is essential for bodily health. Thus, Vitamin A is either itself the hydrocarbon known as *carotene*, or this is its immediate and necessary precursor. Upon its presence depends the health of the skin and other epithelial structures, and also, incidentally, the power of vision at night. In its absence, or if there is a deficiency of it, these structures tend to degenerate and ulcerate, and night-blindness develops. Vitamins B 1 and B 2 are essential for the health of nerve tissues, and it is in their absence that beri-beri and the disease of maize-eating populations known as pellagra appear. The name of *thiamine chloride* has been given to the complex chemical substance identical with vitamin B 1, and it seems probable that *nicotinic acid* is at least in very close relationship with vitamin B 2. Vitamin C, in the absence of which scurvy appears, has been given the name of *ascorbic acid*. Vitamin D, essential to the proper growth of bone and normal calcium-absorption, is probably either *ergosterol* or a product of this following the action of sunlight or ultra-violet rays in association with other sterols. Less is known of Vitamin E, which, however, is closely associated in certain animals with normal reproduction.

Vitamins A, D, and E are soluble in fat. Vitamins B—of which there are several in the same group—and C are soluble in water. The principal food-sources of Vitamin A are liver, fish-oils, egg-yolk, butter, cheese, and various vegetables such as cabbage, lettuce and tomato. The Vitamin B group is to be found in beef, mutton, grain-coverings, peas, beans and potatoes, carrots, cabbages and other vegetables. Vitamin C is contained in oranges, lemons, blackcurrants, strawberries, raspberries, cabbages, lettuces and tomatoes. Vitamin D is contained in the yolk of eggs, and summer-butter, but in the greatest concentration in cod-liver oil and halibut oil. Milk contains all the vitamins but relatively little of Vitamin C. But this list must be taken rather as one of instances than as comprehensive.

Finally, as the result of much careful experimental work and quantitative analysis, a system of international units in respect of vitamin measurement and dosage has now been evolved; and all the above vitamins or immediate vitamin precursors can now be obtained in various tablet, ampoule, or capsule preparations.—(*The Spectator* No. 5881, 1941, p. 277.)

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

THE LEACHING OF POTASH FROM ACID SOILS.

In discussing the changes which have taken place in recent years in the soils of British Guiana it was pointed out that the association of the most obvious cause, the continued application of sulphate of ammonia as fertilizer to the cane lands, with the effect, the growing acidity of the soil to an extent which sometimes showed deleterious action on the crop, might not be the real factor concerned in the soil change noted. If British Guiana offers an outstanding example, it is not the only one, and deleterious effects have been found elsewhere. The cane industry in Hawaii has been erected on a basis of mineral fertilization but the soils here have so far shown no such deterioration and any assumption that such changes will or will not take place at some future date is premature. In an article* by P. L. Gow reference is made to certain unpublished results which indicate that the sugar cane may act as a buffer to changes of pH, tending to restore this to a value approaching that of untreated soil; a conclusion which requires to be correlated with the effect in British Guiana where, also, cane is grown continuously on the same land.

The induced changes take one or more forms; increase in hydrogen-ion concentration (decrease in pH), increase in exchangeable hydrogen, decrease in exchangeable bases (especially calcium) increase in readily soluble aluminium, iron or manganese. The questions asked are: which of these is responsible for the deleterious effect sometimes found in the crop, and will the Hawaiian soils continue to support cane crops under the present practice of fertilization? From theoretical considerations it is argued that a decrease in effective exchange capacity and a resultant inability of the soils to retain potash are the only reactions likely to be dangerous at the present time and these considerations have led to the study now described. In it, lysimeter readings and analyses are reported, in which potash is applied either in the form of muriate of or the basic carbonate. The latter salt was selected since preliminary observations indicated that a very much greater uptake of potash took place in acid soils from this than from the muriate. Though some three times the price of muriate, cheaper sources might be developed if a demand arose.

The experiments described cover four replications of nine treatments, no K, KC_1 with and after N and K_2CO_3 with and after N, the latter four being duplicated, one set with growing cane and one without vegetation. General experience as indicated that complete nitrification in soils of the type used (Manoa soils with a pH of 5.3) has taken place in 45 days with the possible further production of hydrogen ions and for this reason applications of K were made both with the N application and after that period. Pots without vegetation were included in view of the above noted suspected effect of the cane plant.

The three original cuttings of H 109 planted were dug up, one planted and growth limited to one shoot. After four months the shoots were cut back to the seed piece and 14 days later fertilizer applications made, N being supplied as NH_4C_1 at the rate of 100 lb. per acre after a basic dressing of N 100 lb. and P_2O_5 as ammophos 13 to 48 at the rate of 369 lb. per acre added to the soil before filling. Potash was added either at the time or later at the rate of 300 lb. K_2O per acre. The conclusions, thus, are drawn from ratoon canes.

The most striking feature of the results obtained from these experiments is the markedly increased loss of potash by leaching in the absence of vegetation. Thus, while the losses under the various treatments ranged, for cane, from 6.0 to −0.1 per cent. of the amount applied, where no vegetation occurred they ranged from 33.1 to 4.2 per cent. These differences are highly significant. It seems fair, therefore to conclude that increased losses of potash as the result of continued use of acid-forming fertilizers is unlikely in the case of soils cropped, as they are in Hawaii, only to cane. There appears to be a highly efficient uptake of potash by ratoon canes.

Lower losses of potash are also recorded as the result of the use of the carbonate in the pots without vegetation but the differences were hardly significant. A similar but insignificant loss was found in the pots with cane; in fact, it may be said generally that all the losses in the pots containing cane were so small that the effects of the varying treatments were negligible. Such comparisons as are possible, therefore, are limited to the uncropped pots and, in these, the losses were somewhat lower in the pots which received the delayed application of potash.

From the practical point of view the indications are that it is impossible to build up a reserve of exchange-potash in acid soils by the application of an amount in excess of the crop needs. Further, these pot experiments exclude the possible losses which would arise in practice from leaching by heavy rain shortly after application.—(*International Sugar Journal*, Vol. XLII, p. 307.)

CONTROL OF TOMATO DISEASES.

Various chemical treatments have been suggested for the control of soil-borne diseases. Formalin is the most readily available of these, but the liquid has certain disadvantages in practice. W. Brown has briefly reported (*Gard. Chron.*, February 8) good results with an American suggestion to use formalin adsorbed upon an inert carrier such as diatomaceous earth or sawdust. The experiments relate particularly to the damping-off disease of tomatoes caused by Phytophthora fungi, and in some cases a total control of the malady was effected by the use of formalin powder applied to the seed bed, when the seed was sown. Such treatment appears to provide a sustained control of damping-off and not merely to postpone it for a time.

*A Lysimeter Study of Losses of Applied Potash by Leaching from Acid Soil. *Hawaiian Planters' Record*, 43, p. 263.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

The Crow-Bar Method of Applying Artificial Manures.

The fixation of mineral elements essential to the nutrition of crop plants has for years vexed the horticulturist who must of necessity use soils having a relatively high pH and fixation co-efficient. The findings of Fraps (*Tex. Exp. Sta. Bull.* 549, 1937), McGeorge (*Ariz. Agric. Exp. Sta. Tech. Bull.* 40, 1932) and many others have shown that it is practicably impossible to change the reaction of the entire mass of soil surrounding crop plants as a means of releasing potential stores of the minor elements. McGeorge has shown that even the major element phosphorus may become fixed to such an extent that phosphorus-deficiency occurs on some alkaline and saline soils.

A spot or hole method of applying nutrient materials, acidifying agents and disease inhibitors about the crown-roots of horticultural plants has been described (*Proc. Amer. Soc. Hort. Sci.* 37: 1080, 1939): applications of fertilizer materials to annual crops induced the writer to utilize what appears to be a practicable scheme for applying phosphorus and essential minor elements to trees, shrubs and plants not ordinarily grown in rows. Previous experience suggested the use of ammonium phosphate as the source of soluble phosphate; green vitriol (impure ferrous sulphate) as a cheap source of iron, zinc, manganese and copper, and sulphur as an acidifying agent and inhibitor of certain acid-sensitive root-diseases. Field experience, backed by wide-scale trial by commercial florists and home gardeners, seems fully to justify the conclusion that the application of relatively small quantities of the above materials in circles of holes made with a crow-bar or soil auger to a moderate depth will bring about the prompt and lasting recovery of plants affected with a rather common type of deficiency disease. Later tests have included cotton-seed meal as an important constituent of the corrective mixture. Apart from the nitrogen and other elements contained, the decomposing cotton-seed meal is probably a good source of carbon dioxide and vitamin B, and has other beneficial effects on plant growth.

The size of the plants to be treated and the factor of plant safety must be given due consideration in using a method of this kind, which calls for the placement of highly soluble materials (which are toxic in even moderate concentrations) within the active root zone of the plants. The gardener must rely on his own judgment in placing the holes and measuring out the dosage for individual plants. This depends on the type of material used, on the size and condition of the plants, and upon soil-type and condition. There are many variations of the method and a wide range of materials which should be investigated in the near future.—(W. H. Friend in *Chronica Botanica*, VI, 15, p. 350, 1941.)

Proteins in Hevea Latex.

Publications No. 2 of the British Rubber Producers' Research Association brings out a marked resemblance between rubber latex protein and typical leaf proteins. The following table, from G. R. Tristram (*Biochem J.*, 34, 301; 1940), compares his analyses with leaf protein analyses by Chibnall:

	Amino-acids as percentage protein.	
	Latex.	Various leaves.
Ammonia ...	1.46	0.97- 1.17
Arginine... ...	6.90	7.1 - 8.2
Lysine	5.68	4.6 - 6.2
Histidine ...	0.63	1.0 - 1.6
Glutamic acid ...	13.68	11.4 -14.0
Aspartic acid ...	10.5	7.9 - 8.8
Tyrosine ...	7.24	4.8 - 6.1
Tryptophan ...	1.49	2.1 - 2.4
Methionine ...	1.12	2.2 - 2.7
Cystine	1.02	1.4 - 2.2
% Total nitrogen	14.95	12.8 -15.0

The similarity in the two sets of figures undoubtedly suggest some relationship between the proteins in the leaves and latex of *Hevea brasiliensis*, and the question is being pursued by way of analyses of proteins from Hevea leaves themselves.

J. McGavack and C. E. Rhines (*Ind. Eng. Chem.* 32, 1072; 1940) recently showed that the nitrogen content of "whole latex" is approximately constant at 0.25 per cent., the analyses being of 117 samples, collected in a single month (thus avoiding seasonal variation) from many types of tree. There is a suggestion in this constancy that the tree produces some nitrogenous compound to an optimum concentration, either as an auxiliary to the synthesis of caoutchouc or as a side product of that synthesis. Tristram's results thus throw an interesting light on such a suggestion, indicating the place of these reactions as in the Hevea leaves, a natural site for photosynthetic transformations. Further results in this field will be awaited with impatience.—(*Nature*, 147, No. 3737; 1941.)